



Feasibility of an online platform delivery of pulmonary rehabilitation for individuals with chronic respiratory disease

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ABSTRACT

Introduction SARS-CoV-2 has restricted access to face-to-face delivery of pulmonary rehabilitation (PR). Evidence suggests that telehealth-PR is non-inferior to outpatient PR. However, it is unknown whether patients who have been referred to face-to-face programmes can feasibly complete an online-PR programme.

Methods This service evaluation used a mixed-methods approach to investigate a rapid PR service remodelling using the University of Gloucestershire eLearn Moodle platform. Quantitative baseline demographic and PR outcome data were collected from online-PR participants, and semistructured interviews were completed with PR staff and participants.

Results Twenty-five individuals were eligible from a PR waiting list. Thirteen declined participation and 14 completed PR. Significant pre-post online PR improvements were achieved in 1 min sit-to-stand (CI 2.1 to 9 (p=0.004)), Generalised Anxiety Disorder (CI -0.3 to -2.6 (p=0.023)), Primary Health Questionnaire-9 (CI -0.3 to -5.1 (p=0.029)), Chronic Respiratory Questionnaire dyspnoea (CI 0.5 to 1.3 (p=0.001)), fatigue (CI 0.7 to 2 (p=0.0004)), emotion (CI 0.7 to 1.7 (p=0.0002)), mastery (CI 0.4 to 1.3 (p=0.001)). Interviews indicated that patient PR inclusion was made possible with digital support and a PR introduction session improved participant engagement and safety. Incremental progression of exercise was perceived as more successful online compared with face-to-face PR. However, perceptions were that education sessions were less successful. Online-PR required significant staff time resource.

Discussion Online-PR improves patient outcomes and is feasible and acceptable for individuals referred for face-to-face PR in the context of a requirement for social distancing. Face-to-face programmes can be adapted in a rapid fashion with both staff and participants perceiving benefit. Future pragmatic trials are now warranted comparing online-PR including remote assessments to centre-based PR with suitably matched outcomes, and patient and staff perceptions sought regarding barriers and facilitators of online delivery.

BACKGROUND

During the SARS-CoV-2 pandemic, face-to-face delivery of pulmonary rehabilitation

Key messages

- Can patients on pulmonary rehabilitation (PR) waiting lists feasibly complete online-PR programmes? If so, how do staff normalise the process of providing online-PR within existing NHS services?
- Online-PR is deliverable, patients think it is feasible and patient outcomes are improved.
- To our knowledge, this is the first online-PR evaluation using staff experiences, feedback from patients and PR outcome data, using a novel online platform not previously used in the context of PR.

(PR) stopped due to UK national lockdown and social distancing rules. People with chronic respiratory disease (CRD) have suffered as a result, particularly psychological impacts including anxiety, loneliness and concerns about personal health.¹ Loneliness, domestic isolation and social disengagement are longitudinally associated with poorer physical performance in older adults² and shielding during COVID-19 has reduced physical activity levels of patients with CRD.³ Therefore, it is important to enable individuals to continue receiving interventions which promote physical activity, which are useable for staff and patients during the pandemic. Evidence suggests that providing home PR is feasible and comparably effective to face-to-face delivery when performed as part of a randomised controlled trial (RCT).⁴⁻⁷ Furthermore, tele-rehabilitation has previously been shown to improve exercise capacity, symptoms and psychological comorbidity in patients with COPD as part of an RCT.⁸ It has also been shown that other group programmes for individuals with CRD can be feasibly delivered online such as Singing for Lung Health groups.⁹ The Association of Chartered Physiotherapists in Respiratory Care state that only 50% of PR programmes

surveyed provide remote-PR via video-conferencing or web-based platforms and report that it is essential that such options are evaluated following implementation.¹⁰ Other national survey data suggest that only 22% of clinicians surveyed provide remote-PR.¹¹ The two web-based platforms currently recommended for remote-PR include myCOPD and SPACE for COPD.¹⁰ Further platforms warrant evaluation. We aim to provide such an evaluation, focused on programme outcomes, staff normalisation of online-PR delivery within other service demands, and we sought patient feedback regarding feasibility.

METHOD

The study design used a mixed-methods approach. Qualitative data were analysed using thematic analysis of patient and staff experiences.¹² Participants provided consent to participate. The deductive analysis of staff experiences was specifically aligned to normalisation process theory (NPT).¹³ According to May and Finch¹³ NPT 'is concerned with the social organization of the work (implementation), of making practices routine elements of everyday life (embedding), and of sustaining embedded practices in their social contexts (integration)'. The social context within this study related to the organisation and practices of a Community Respiratory Team. Interview questions were aligned to areas of intervention content and delivery, design conduct and process and outcomes.¹⁴ Data were familiarised, listening to the interviews repeatedly, writing, reading and re-reading transcripts. The transcripts were then tagged with phrases using the comment function in MS word. Codes were then transferred and grouped into larger meaning units which were then reviewed once all transcripts had been coded. Themes were developed, reviewed and defined on review of the codes in relation to the reference text from the interview and understanding of NPT. Semistructured interview guides are provided in the online supplemental appendices. Staff are referred to by participant number and online-PR participants have been given pseudonyms.

Statistical analysis

Quantitative analyses were performed using SPSS 26. Feasibility outcomes of attendance were calculated with percentages. Feasibility was determined according to UK National PR Audit data whereby 42% of those referred to a programme completed PR.¹⁵ Normality of other outcome data was assessed visually according to histogram and box plots in combination with assessment of the Shapiro-Wilk test at a significance level of $p < 0.05$. Accordingly, independent sample t-tests, Mann Whitney U and χ^2 tests were performed to compare demographics of those who were assessed compared with those who declined participation on the online-PR. Paired sample t-tests and Wilcoxon signed rank tests were performed for baseline and follow-up objective outcome measures.

Patient and public involvement

Patients and members of the public were not involved in the development of this project due to the rapid remodelling of service delivery. However, staff and participant views contained within this service evaluation will help inform further research.

Procedures

The learning management system used was Moodle, named 'eLearn' within the University of Gloucestershire. There was functionality for video conferencing, messaging groups and individuals with text using the keyboard and a messaging pane, or via microphones embedded within the computer. Further information about the online platform is provided in the online supplemental appendices. Assessments were carried out virtually at a time convenient to the participant. A full history of present condition, medical history, drug and social history, a detailed falls history and falls checklist was completed. Inhaler technique was checked, pulse oximetry and all outcome measures were taken during these assessments. The online-PR exercises were developed by an exercise specialist and groups were moderated by clinicians. Further details of the exercise component and risk assessment are provided in the online supplemental appendices. The online course was provided to patients two times a week for 6 weeks and patients also received one-to-one phone calls with a clinician at weeks two and four. Further details of the online programme are found in [table 1](#).

Participants

Participants with CRD who were referred to the community respiratory team for face-to-face PR were screened for eligibility to participate according to British Thoracic Society guidance.¹⁶ Eligible potential participants were recruited from caseloads of cancelled PR classes and invited to attend by telephone. Convenience sampling was used for interviews of participants with CRD and staff members of the online-PR programme.

RESULTS

Thirty patients were screened and 25 fit the eligibility criteria for PR. Thirteen patients declined commencing online-PR (no internet access (n=3), low confidence in using technology (n=3), personal preferences (n=3), four of whom had undocumented reasons, two felt self-conscious using web-cameras). Seventeen were assessed and started the programme and 14 patients completed at least 9 out of 12 sessions and therefore deemed completers. There were no adverse events. Clinicians moderating groups were able to take participants into a breakout space if an adverse event were to occur. The moderator had access to participant and next of kin contact details. Further details are provided in the participant flow diagram (online supplemental appendices figure 1).

Table 1 Adaptions made for online delivery of PR

| Traditional face to face programme | Online-PR delivery |
|--|---|
| Face-to-face patient assessments | Online video-based assessments |
| Incremental shuttle walk test exercise capacity outcome | 1 min sit-to-stand exercise capacity outcome |
| Progression to 3 min per endurance exercise | Progression to 4 min per endurance exercise |
| Clinician led exercise | Exercise instructor led exercise |
| Resistance exercises with free weights | Resistance exercises with Theraband |
| Group education delivery within sessions | Separate individually accessed education |
| No preliminary patient home visit | Patient home visit for equipment delivery and IT platform training as needed |
| No prior equipment provided | Theraband, oximeter and sometimes Ipad delivered |
| Home exercise programme administered on session one (paper based) | Home exercise programme administered once patient confident with online participation (paper based) |
| Community hall venues | Patient home venue |
| MDT education including: Understanding your lung condition, breathlessness management including input from psychological therapist, cough and sputum, planning for future, nutrition, benefits of exercise, hospital care, medications and inhaler technique | MDT education including: Understanding your lung condition, breathlessness management including input from psychological therapist, cough and sputum, planning for future, nutrition, benefits of exercise, hospital care, medications and inhaler technique. |
| Introduction session before preassessment including expert patient experience | Introduction session following pre-assessment led by exercise specialist and clinician |
| Paper based Patient-rReported Outcome Measures, missing data entry possible | Digitally completed outcome measures, submission not possible without complete data entry. |
| Clinical notes written on System one | Clinical notes written on System one |

PR, pulmonary rehabilitation.

Baseline demographics

Table 2 presents the baseline demographics of participants.

Quantitative outcomes

Table 3 presents pre-post PR outcome data.

These data indicate that 6 weeks of online-PR participation significantly improved all outcome measures of exercise capacity, anxiety, depression and respiratory related quality of life.

Qualitative data—staff

All four staff members providing online-PR were interviewed. Staff members included a team lead physiotherapist, other physiotherapist, nurse and exercise instructor. Analytic themes were aligned to the components of NPT including coherence, cognitive participation, collective action and reflexive monitoring.

Coherence (the meaningful qualities of practice)

On the background of patient deterioration, in the absence of other care provision, the ethos of providing

Table 2 Participant baseline demographics

| Demographics | Started online-PR (n=17), Mean (SD)/median (IQR) | Declined online-PR (n=13), Mean (SD)/ median (IQR) |
|--------------------------------|--|--|
| Gender ♀♂ | 9/8 | 6/7 |
| Age | 69.7 (10.7) | 72.9 (10.8) |
| BMI | 26.6 (13.6) | 26.6 (10.4) |
| Diagnosis | 15 COPD 1 ILD 1 Asthma | 11 COPD 1 ILD 1 Asthma |
| MRC | 3 (1) | 3 (0.75) |
| Owned own computer/laptop | 12 (70.5%) | 7 (53.8%) |
| Previous face-to-face sessions | 5 (4.5) | 5 (5.5) |

BMI, body mass index; MRC, Medical Research Council.

Table 3 Outcome measure changes from participating in online PR

| | Baseline (n=14) | 6-week follow-up (n=14) | Delta | CI (p value) |
|--------------|-----------------|-------------------------|------------|----------------------|
| 1 min STS | 15.5 (5.3) | 21.1 (7.8) | 5.6 (6) | 2.1 to 9 (0.004) |
| GAD | 4.8 (4.6) | 2.7 (3.3) | -2.1 (3) | -0.3 to -2.6 (0.023) |
| PHQ | 7.9 (5.1) | 5.2 (5.5) | -2.7 (4.1) | -0.3 to -5.1 (0.029) |
| CRQ dyspnoea | 3 (0.9) | 3.9 (1.1) | 0.9 (0.7) | 0.5 to 1.3 (0.001) |
| CRQ fatigue | 3.3 (1) | 4.7 (1.3) | 1.4 (1.1) | 0.7 to 2 (0.0004) |
| CRQ emotion | 4 (1) | 5.2 (0.9) | 1.2 (0.9) | 0.7 to 1.7 (0.0002) |
| CRQ mastery | 4.4 (1.1) | 5.3 (1) | 0.9 (1.3) | 0.4 to 1.3 (0.001) |

CRQ, chronic respiratory disease; GAD, generalised anxiety disorder; 1 min STS, One min sit to stand; PHQ, Primary Health Questionnaire; PR, pulmonary rehabilitation.

online-PR was for it to be as inclusive as possible for patients. This inclusivity was made possible by significant digital optimisation, repeated communication between patients and staff, and continuity of care provided by team members.

If someone needed an iPad, we can't obviously post that, I would have to go and show them how it all works and explain to them, get them logged in...that would take anywhere from half-an-hour to an hour at their house. (Participant 4)

The delivery of online-PR should be flexible for clinical workloads and alternate service provision while fitting into the daily lives of patients with respiratory disease.

We think it offers us the option to work slightly longer days or more flexibly...we think it's an option for those people who potentially still in work who can't come to a face-to-face group. (Participant 1)

Non-clinical staff engagement, commitment and leadership are essential, and patient safety and exercise progression as a group are of paramount concern.

It was unknown, we were taking a risk, so we kind of discussed a lot about safety, about keeping the patients safe, about having a risk assessment of the actual process. (Participant 3)

Cognitive participation (enrolment and engagement of individuals or groups)

Delivering face-to-face PR was not an option or feasible in relation to community spaces and patient appetite.

But I don't think the risk appetite to do that will be there, in the real world actually, are we going to get five people who want to come to a group of people who cough and sneeze and splutter? (Participant 2)
Social distancing, we couldn't replicate what we are delivering now in any kind of physical environment with restrictions. (Participant 1)

Plans for PR development were long-standing prior to the pandemic due to a lack of uptake in the traditional

format. Patients were already becoming accustomed to using alternative digital platforms for other social affairs, although some frustration remained using IT. An iteratively designed introduction session improved engagement and safety.

Now the introductory session goes over you know very clearly what the expectations are if you're an oxygen user. (Participant 1)
Adding in that introduction session definitely helped, as we were able to see who was having the tech issues and things beforehand. (Participant 4)

Unlike face-to-face PR, patients exercised as a group, which made delivery and monitoring easier, and improved overall volumes of exercise completed. Because of the high standard of work provided by non-clinical staff, once participants were set up on a programme there was limited clinical work involved, which enabled other services to benefit such as oxygen therapy prescription.

I don't feel like I'm doing a huge amount of clinical work with this online stuff. (Participant 2)

However, a significant amount of staff time was required to enable the beneficial outcomes.

Once people are on the course, that's kind of the easy part, I think its selecting people to get on, getting them to agree, then they've got to have a pre-assessment, and before they have a pre-assessment they'll need their pulse oximeter and, after their pre-assessment they've got to be posted all the paperwork and things, we need to make sure everyone knows how to log onto eLearn...before they actually start is the most time consuming part. (Participant 4)
Now you've got to have a third person for the first, I don't know four sessions to deal with the IT. (Participant 2)

Collective action (interaction with already existing practices)

Necessary adaptations to the service were required to cater for the frail, new oxygen users and those with IT issues, although all could be reasonably catered for.

They had this sense of achievement that they'd mastered technology...I saw more frustration with NHS transport getting patients to pulmonary rehab face-to-face than I have ever seen on you know online. (Participant 4)

Incremental progression of exercise was perhaps more successful than during face-to-face delivery, and levels of effort regarding breathlessness and perceived exertion were effectively monitored, with Borg scales incorporated into online delivery.

They were the same exercises each week, but we started with two minutes per exercise and over the course of the six weeks we increased it to four minutes so doubling their time. (Participant 4)

Patient outcomes improved accordingly. Exercise delivery was straight-forward. However, engagement in education was not as successful.

In a (face-to-face) group setting you'll maybe recap week-to-week... ask them questions about what they've learnt before and judge their understanding, you don't get to do that in the online world, the reality is although you phone them twice, you'll often say, "right what do you want to ask me, from what you've watched online" and they, 9/10 they'll say "oh nothing", so you're not sure how much they're engaging in the education. (Participant 1)

If we can make the education a bit more bitesize, a bit more segmental, it might be beneficial so people can come back to it. (Participant 2)

They only need to click on the section for it to go green, they don't have to watch the video. (Participant 4)

Expanded provision of online-PR was planned regarding winter pressures. However, it was not clear whether resource or other service demands would allow this.

Reflexive monitoring (how a practice is understood or assessed by actors in it)

Although outcomes were positive, not all outcomes were assessed, and the quality of care provided to patients compared with face-to-face PR should be questioned further. Prior to the offer of online-PR, patients were deteriorating and desperate for some provision of clinical support and with other parts of life locked down any offer was hugely well received. However, rapport between patients and staff was difficult to foster, holistic patient assessment was harder, cameras had to be muted and sessions were unidimensional regarding exercise.

Rapport you would normally have with a patient, I think you lose. (Participant 3)

If someone comes in and they're very wheezy and they're struggling, I think they can hide it a bit more on the camera maybe and I don't get to know the patients, so I can watch them exercise but I don't get

that engagement through delivering the education and what some of their other problems might be. I think one of the best things about doing the face-to-face PR with a clinician...is that we pick up on lots of little things that can improve someone's condition whether that might be some different techniques they might want to try, changes to medication, other health things, signposting to different services things like that which I'm not sure we'll pick up with an online course. (Participant 2)

Education engagement, delivery and assessment require significant improvement and innovation.

I think the education we can think much more carefully about...I think there's scope to be really really creative, with the online platforms. I think we can look at sort of education theory that we would look at for university students, we could look at how do people learn. (Participant 3)

Individual patient attention was stifled at times because of technology, and patients were reluctant to engage with each other without clinician attendance. These potential pitfalls were put into context of an appetite to use what has been learnt from the online-PR service and continue to implement and adapt face-to-face delivery:

We don't have the time to kind of ask patients about too much "how much did you access?, what bits did you enjoy?"...maybe I should delve a little bit into which bits they've engaged in or not to see how much they're engaging in it. (Participant 2)

The important ethos of the staff was continuing to offer a choice of participation for all:

Lots of people have questioned, "well what about people who haven't got access to technology?" Which obviously makes it, if people haven't got access, it does make it inequitable. However, I would come back at those people and say, "yeah, but in face-to-face you've also got the people who can't get there, who are severely disabled" so by default traditional face-to-face pulmonary rehab could be deemed inequitable or if people are frightened, or lack confidence with groups of people. (Participant 3)

We feel what we are doing is the most sensible way for us to behave over winter. (Participant 1)

Online-PR participant data

Four participants who completed online-PR delivery were interviewed. Two men and two women with an average age of 62 (SD: 13) all had COPD. Thematic analysis from these interviews developed three themes including digital literacy, effectiveness of programme and comparability of models. Further example quotes and codes are provided in the online supplemental appendices.

Digital literacy

Any problems participants had with the technology could be overcome, and although frustrating, they were not perceived as insurmountable barriers.

I don't find the tech that easy but once it's up and running its OK.

(Neil)

Pictures on the site make it easier.

(Sheila)

Teething problems were also reported which reflects the staff experiences:

The first week wouldn't work on laptop

(Neil)

Effectiveness of programme

Patients also perceived the online programme to be beneficial, noticing functional improvements in their activities of daily living.

It encouraged me to get walking again ... I started off with half a mile and the last one I did was 1.2 miles. I'm pleased with that, my goal is 2 miles.

(Neil)

I used to have a mattress downstairs and I don't use it anymore. I do the housework now and garden. Huge difference.

(Rob)

Patients reported that there was 'no choice' and that they either participated in the online PR offer or received nothing.

Comparability of models

Individuals found the online group comparable to face-to-face groups, stated some benefits of doing the exercises at home compared with in a group, but noted that group interaction was lacking.

There was no difference between doing it online or in a group.

(Sheila)

There are a few differences with the exercises but I found it (online) better. I was doing too much (exercise) in a group because it was longer. They (exercises) were the same time but we got more rest periods online.

(Rob)

I felt more comfortable at home doing the programme.

(Rob)

It would be better face-to-face but you've got to go with what's available, a lot of it is outside of our control.

(Jackie)

DISCUSSION

This service evaluation indicates that providing online-PR for patients with CRD improves patient outcomes and is a feasible alternative to face-to-face delivery in the context of a requirement for social distancing. Seventeen out of 25 (68%) patients were able to transfer appropriately from face-to-face to online delivery during COVID-19 and 14/25 (56%) completed PR. Fourteen out of 17 (82.3%) enrolled completed, which also achieves more than the threshold National PR audit recommendation C3 of 70% completion.¹⁷ Hansen *et al*⁵ previously have shown that completion rates of tele-rehabilitation can be higher than face-to-face models when judged by participants remaining in either the tele-rehabilitation group (49/67) or traditional PR (43/67) for the full intervention period. Furthermore, a recent Cochrane review on tele-rehabilitation in CRDs concluded from a meta-analysis of three studies that individuals were more likely to complete a minimum percentage of prescribed sessions during tele-rehabilitation compared with face-to-face PR (OR 5.36, 95% CI 3.12 to 9.21; 516 participants).¹⁸ The completion threshold in our study is likely higher than the pooled minimum percentage used in the Cochrane review. Our mixed-methods findings in this study offer support for these figures in the context of SARS-CoV-2; this may occur because of limited resources and patient appetite as described in our study. Benzo *et al*¹⁹ performed a feasibility study of an 8-week video-based physical activity and health-coaching intervention for individuals with COPD. Their study indicated that patients were highly adherent to the home programme with high levels of satisfaction. In comparison to Benzo *et al*'s study,¹⁹ the exercise frequency was lower and intensity higher in our study. Furthermore, exercises were performed live in a group with supervision and assessment by physiotherapists, therefore meeting the definition of PR. Our study also used different outcome measures and qualitative analyses which further develop understanding. For example, Participant 4's experience above offers further potential insight regarding Benzo *et al*'s¹⁹ report of 100% completion of many activities such as 'watched how-to videos'. It is possible the participants pressed a button to indicate they completed this component without actually watching the videos.

There were no statistically significant differences between the online-PR starters and those who declined regarding baseline demographics in our study. 16.7% fewer online-PR decliners had their own PC or laptop compared with online-PR starters. This difference was not statistically significant (χ^2 test $p=0.494$). This could be a type two error in relation to the small sample size in this study.

Staff were able to normalise the process of online provision within their wider clinical service. There were barriers and limitations which were highlighted, including issues with IT, education provision and capability to provide patient support and quality of patient care and self-management. Issues with IT access, competency

and motivation for an online format were reported. This reflects a recent survey results by Polgar *et al*²⁰ who state that out of 193 PR service users 31% had never used the internet and 29% had no interest in using a digital platform. This contrasts somewhat from findings by Seidman *et al*,²¹ who reported that out of 254 patients with CRD surveyed 70% regularly use a computer or tablet and 60% were willing to use tele-rehabilitation. Our service evaluation shows that although some patients did not want to participate in an online programme, other issues of IT could be overcome, by providing personalised equipment and one-to-one technical support in patient homes. Other options are highlighting wifi-hubs in the community and contacting digital champions in primary care services for example. In fact, online-PR delivery has been reported as a solution to enabling improved patient digital health skills, by incorporating such information in education sessions.²² Furthermore, a previous pilot of home-based online-PR suggests that such platforms are useable by participants and economically viable.²³

Quantitative results indicated that the service evaluation programme was successful at improving functional exercise capacity, anxiety and depression (which was clinically significant at baseline) and multiple domains of disease-specific health-related quality of life. A previous threshold has been established by Puhan *et al*²⁴ in which those individuals who have a 1 min sit to stand test of at least 19.5 have a lower mortality risk at 2 years. Participants within this service evaluation crossed this threshold, as well as the MCID of three repetitions.²⁵ This improvement may have been possible due to the focus of regular incremental increases in endurance exercise time. All individuals completed both physical and questionnaire-based outcomes successfully, both at baseline and follow-up, indicating that traditional PR outcomes are feasible and have transferability to an online delivery format. Nevertheless, 56% patient completion is suboptimal. Further research is needed to improve uptake and completion.

Strengths and limitations

This service evaluation reports results from using the Elearn platform in the context of PR using remote and video-based patient assessments. The use of eLearn and the working partnership between academic and NHS institution is important. Once someone in the University organisation opens the platform for a clinical service, an unlimited amount of patients can benefit from its use at no additional cost. In the context of scaling up delivery, this will be an important consideration for many services grappling with increased patient workloads over the winter and continuing SARS-CoV-2 working practices. Furthermore, remote assessments are the most practical and relevant format for patients participating in online-PR. Previous trials in tele-rehabilitation have still required patients to attend face-to-face clinical

assessments before and after PR which may not be fit for purpose in the COVID-19 era.

These results are from one clinical service evaluation, using one online digital platform, with a small sample size, and therefore may have limited external validity. Furthermore, the majority of participants had already participated in some face-to-face PR sessions. Moreover, there was no control group in the study and it is not clear to what extent outcomes would have changed with usual care.

Future research

Further pragmatic trials are required whereby patients are offered the choice of face-to-face compared with online-PR delivery. Patient choice has been considered in similar comparison of home-based versus outpatient-based PR successfully,²⁶ but regular video-based intervention was not part of the home-based intervention in this cohort study. Interventions should be matched for principles of exercise training and education provision, but necessary alterations are required for online delivery, regarding space available, instruction and patient individualisation of care, which all need to be considered. Further research is also required to understand the best methods of providing digitally delivered patient education.

CONCLUSION

This service evaluation investigated the outcomes, staff normalisation practices and feasibility of providing an online PR programme during SARS-CoV-2 pandemic. Online-PR improved clinical outcomes and was feasible to deliver. Patients found it acceptable, and clinicians adapted their workloads and normalised the online delivery as part of ongoing service provision. Future pragmatic trials are now warranted and focusing on improving online education delivery as part of PR is essential.

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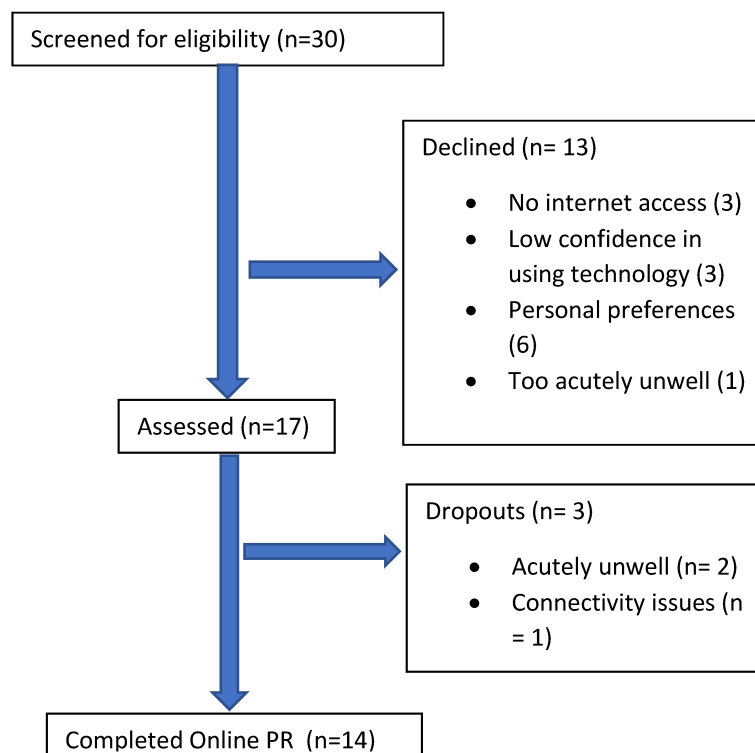
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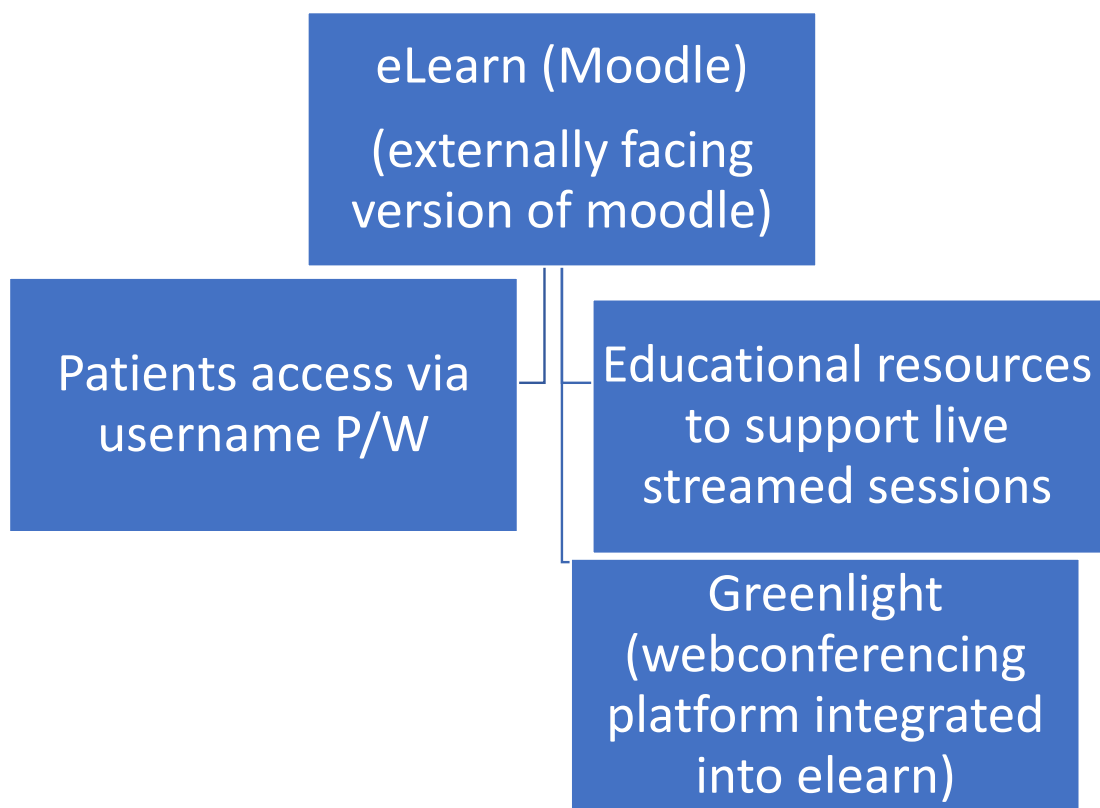
Appendices

Figure 1: Flow diagram of recruitment and completion of online PR:
Consort diagram

Online platform set-up and access

Remote delivery of the pulmonary rehabilitation programme was via an integrated system of learning platforms normally used for student education at the University of Gloucestershire (UOG). Access to the system for patients and pulmonary rehabilitation staff was gained via a username and password allocated by the university's Library Technology and Information (LTI) Service. The process was supported by a designated member of university staff (EBS) working alongside a Learning Technologist from the University Academic Development Unit (ADU). There were no additional cost implications for the university in terms of IT resources. Entry to the learning platform was via software called 'eLearn'; an externally facing version of Moodle™. Moodle™ is an online learning platform, widely used in educational institutions, via which educators can create personalised learning environments for their students (<https://moodle.com/about/>). The platform is used creatively to provide a whole plethora of pedagogical interventions as it has the capacity to integrate other online systems once customised by the LTI service. One of these systems is a web-conferencing platform called 'BigBlueButton' (<https://bigbluebutton.org/>) with its externally facing element called 'Greenlight'. Greenlight allows live-streaming of sessions to an audience and has familiar videoconferencing features such as chat / messaging, screenshare, digital whiteboard use, breakout rooms and screen presentations. The technological specifications of the digital platform and delivery process were scrutinised by the NHS IT department for safety and confidentiality in the context of data protection guidelines. Patients needed to have access to the internet via a suitably enabled digital device in order to participate. All the learning resources such as handouts, videos, links to internet resources etc were uploaded to eLearn. From the eLearn landing page patients would then click onto the Greenlight section which would open the livestreamed exercise and education sessions. Patients were able to switch device microphones on during each session for discussion.

Figure 2: Online PR delivery flow technical flow diagram



Staff Semi-structured interview guide

Consent.

Purpose of interview – experiences of set up, delivery and evaluation of online programme

1. Context – tell us a little about your current professional role and background in pulmonary rehabilitation
2. Tell me about your experience of setting up the programme for online delivery
 - What was difficult, what have you learnt, were there any surprises
3. What patients have been eligible? – currently enrolled, on waiting list, exacerbators
4. Talk me through what you have been doing regarding patient assessments and re-assessments.
 - What has gone well? Any concerns
5. Discuss the particular components that you have included as part of the programme
 - Exercise, education, home practice, other support.
 - What changes have been required compared to the traditional model
6. How does your practice in delivering the Pulmonary Rehabilitation compare with that of face-to-face delivery?
 - Working in an MDT?
 - Working with patients
 - Governance and organisation?
 - Thoughts on evidence based practice?
7. What onward support or advice do you give patients at the end of the programme

Online-PR participant semi-structured interview

General into

How are you feeling today?

Tell me a little about yourself

Online- PR

Before the COVID crisis did you attend any group therapy sessions for your condition for example Pulmonary rehabilitation / singing groups / exercise classes?

What are your thoughts about doing a group class online?

Talk to me about what you think the differences are?

Is there anything you've not really thought of?

Where I think something is useful, can follow this thread

How you felt it went

What benefits if any are you getting?

What do you mean by this?

Tell me more

Can you give examples?

Technology

Discuss ease of technology

How have you found the technology?

Zoom classes and Elearn access

Have you used this sort of technology before?

Format of the programme

Talk to me about the format of the rehab

Is there anything really good?

Is there anything that can go?

Online-PR participant example coding and quotes

| Themes | Codes | Supporting statements |
|----------------------------|---|---|
| Digital literacy | <p>Teething problems with required technology for PR programme</p> <p>Relationship between participant's digital literacy and digital competence</p> <p>Facilitation from staff and family</p> <p>Elicited success</p> <p>Simplicity of the online platform facilitates participant use</p> | <p><i>"the first week wouldn't work on laptop".</i></p> <p><i>"I don't find the tech that easy but once it's up and running its OK"</i></p> <p><i>"Pictures on the site make it easier".</i></p> <p><i>"Got it set up on my son's laptop then it was working OK – my son's more technically minded than me".</i></p> <p><i>"I had problems logging on -I tend to do it on my son's laptop".</i></p> |
| Effectiveness of programme | <p>All the components of the programme effective</p> <p>Exercise</p> <p>Education</p> <p>psychological interventions)</p> <p>perceived as beneficial.</p> <p>Perceived improvements in traditional PR outcomes</p> <p>Increased levels of physical activity</p> <p>Breathlessness</p> <p>mental health</p> <p>confidence and motivation</p> | <p><i>"It encouraged me to get walking again ... I started off with half a mile and the last one I did was 1.2 miles. I'm pleased with that my goal is 2 miles".</i></p> <p><i>"I've benefitted because I can shower, walk around house, take the dog for short walk".</i></p> <p><i>"It's really good. It's helped my mental health. I'm not so depressed".</i></p> <p><i>"I've more motivation to move about".</i></p> <p><i>"I used to have mattress downstairs and I don't use it anymore. I do the housework now and garden. Huge difference".</i></p> <p><i>"These courses are amazing. They give you more information than the doctors. I learnt things I didn't know - my BMI for example".</i></p> <p><i>"It's amazing – anyone with my condition - I wish they would do this course; it motivates you".</i></p> |
| Comparability of models | <p>Online PR comparable to face to face PR.</p> <p>Favourable experience of online PR in context of global pandemic.</p> <p>Individual exercise progression</p> <p>Group interaction occurs online but less so than face to face PR</p> | <p><i>"There was no difference between going it (PR) online or in a group"</i></p> <p><i>"There are a few differences with the exercises but I found it (online) better. I was doing too much (exercise) in a group because it was longer. They (exercises) were the same time but we got more rest periods online".</i></p> <p><i>"I Felt more comfortable at home doing the programme".</i></p> |

| | | |
|--|---|--|
| | <p>Improved group interaction with increased use of online platform features.</p> <p>Acclimatisation to online environment fostered effective adaptations to communication methods.</p> | <p><i>"We did more exercises in the (face to face) group – so I got more breathless and fatigued. I Feel like it's the right amount of exercise online"</i></p> <p><i>"They can send me stronger wristbands (therabands) if its too easy. I progressed up the difficulty – I started with yellow and progressed up the colours – I now have a black"</i></p> <p><i>"The benefits of doing it at home was that we couldn't do it in a group. It was the only option. And it has worked. I would recommend it. It would be better face to face but you've got to go with what's available – a lot of it is outside of our control"</i></p> |
|--|---|--|

Pulmonary Rehabilitation Class Exercises

Below is a summary of exercises completed during the 6 week online pulmonary rehabilitation course. It is recommended to complete the session in full 3 times a week.

Warm up:

Complete each step of the warm up for 30 seconds (5 minutes in total)

1. Seated toe and heel taps
2. Seated march with arm swings
3. Turn head side to side
4. Roll shoulders forwards and backwards
5. Reaching across your body and twisting your trunk both ways
6. Arms relaxed by your sides, leaning towards the floor both ways
7. Heel digs to each side
8. Standing march – add punching to the front
9. Standing march – add arm bends
10. Start with a small march, make the movement bigger for a count of 5. Repeat this 3 times.

Aerobic Exercises:

Complete each exercise for 3-4 minutes. You should feel a 3-4 on the BORG breathlessness scale whilst completing the exercises. This means you should feel moderately to somewhat severely breathless.

1. Marching on the spot

You can do this standing or seated. Make the movement bigger if you are not feeling breathless.

2. Side step to front punch

Step out to one side with both feet and punch twice to the front. This movement can be done seated. You can lunge further out to the side to make the movement harder.

3. Star Jacks

Move one leg and one arm out to the side simultaneously and then bring them back to the centre. Do the same the other side and repeat. You can do this seated or lunge further out to the side to make it harder.

4. Knee through

Use a chair in front of you for balance if needed. Place one leg behind the other and drive the leg behind through and up towards your chest. Then place the same leg back behind and repeat the movement. Complete half the time on one leg and half the time on the other.

5. Punch with a twist

Place one foot in front of the other for balance. The foot behind is the same side as the arm you will punch with. Punch forwards and twist your torso simultaneously. Bring arm back to neutral position and repeat movement. Complete half the time on one arm and half the time on the other.

Strengthening Exercises:

Aim to complete 10 repetitions of each exercise 3 times. This means you will do a total of 30 repetitions of each exercises with a break after 10 repetitions.

1. Sit to stand

Stand up straight from a chair. Slowly lower yourself back into the chair and repeat. You can use your arms to help push yourself up if you need to.

2. Bicep bends

Start with arms down by your side. Bend arms upwards, keeping elbows tucked into waist at all times. Weights or a resistance band can be used to complete this exercise.

3. Squat to heel raise

Use a chair in front of you for balance if needed. Ensure you keep a straight back and look straight ahead when squatting.

4. Side raise

Use either weights or a resistance band. Keep palms facing down and arms straight as you are bringing them out to the side.

Cool Down:

Hold each stretch for 30 seconds both sides.

1. Start with marching and make the movement smaller over 1 minute.
2. Take a seat and tap your toes and heels for 30 seconds.
3. Neck stretch – put your ear towards your shoulder
4. Roll shoulders forwards and backwards
5. Back stretch – interlink fingers and push arms out in front of you as if you were hugging a tree. Look down.
6. Chest stretch – put both hands in the small of your back and push shoulder back. Look ahead of you.
7. Side stretch – relax both arms by your sides. Lean towards the floor both ways.
8. Leg stretch – place both hands on one bent knee and straighten your other leg. Lean forwards and feel the stretch in the back of your leg.

Risk Assessment Form

| | | | | | | | | | | |
|-----------------|--|---------------------------|----------------|--------------------|---|---|----|----|----|----|
| TASK | <i>Risk assessment of home PR – SPACE and ELEARN</i> | ASSESSMENT No | | Consequence | | | | | | |
| | | | | | 1 | 2 | 3 | 4 | 5 | |
| Source | | Date of Assessment | 31/07/2020 | Likelihood | 1 | 1 | 2 | 3 | 4 | 5 |
| | | | | | 2 | 2 | 4 | 6 | 8 | 10 |
| | | | | | 3 | 3 | 6 | 9 | 12 | 15 |
| | | | | | 4 | 4 | 8 | 12 | 16 | 20 |
| | | | | | 5 | 5 | 10 | 15 | 20 | 25 |
| PREMISES | <i>Own home</i> | PERSON RESPONSIBLE | Clinician Name | | | | | | | |

| Ref No | Hazard | Person(s) exposed to Hazard | Risk Identified | Pure Risk Rating | | | Control Measures Required | In place | | Residual Risk Rating | | |
|---------------|---|------------------------------------|---|-------------------------|----------|----------|---|-----------------|----------|-----------------------------|----------|----------|
| | | | | C | L | R | | Y | N | C | L | R |
| 1 | Room size not sufficient to allow people to move easily during exercise | patient | Risk of injury to patient during exercise | 1 | 1 | 1 | Environmental checklist provided for patient to assess own environment. | Y | | 1 | 1 | 1 |

| | | | | | | | | | | | | |
|---|---|----------|---|---|---|---|--|---|--|---|---|---|
| | | | | | | | Clinician to view proposed space as part of virtual pre-assessment. | | | | | |
| 2 | Objects or equipment on the floor in the room constituting a trip hazard. | patient | Risk of falls | 1 | 1 | 1 | Detailed falls assessment for patients with history of falls at pre-assessment. Rockwood frailty score to identify those more at risk of falls. Environmental checklist. | Y | | 1 | 1 | 1 |
| 3 | Temperature of room during exercise (excessive heat or cold) | Patients | Risk of dehydration or heat exhaustion in hot conditions. | 2 | 1 | 2 | Temperature should be at least 13°C minimum (ideally between 18 and 23°C). If the temperature exceeds 23°C a decision can be made to not exercise on that particular session using poll on ELearn. Open windows for ventilation. Patients on Elearn to refer to 'When not to exercise' guide. | Y | | 1 | 1 | 1 |

| | | | | | | | | | | | | |
|---|--|-----------------|---|---|---|----|--|---|--|---|---|---|
| | | | | | | | | | | | | |
| 4 | Technology preventing sharing of webcam/ being able to hear class lead | patients | Injury due to unsupervised exercise | 3 | 1 | 3 | Webcams to be activated at all times Tech support by staff member if webcam dropping out IPad to be provided where necessary | Y | | 1 | 1 | 1 |
| 5 | Theraband damage causing snapping and potential injury | patients | Muscular injury due to incorrect usage | 3 | 1 | 3 | Instructions on checking theraband for tears prior to every class. Multiple bands issued. | Y | | 1 | 1 | 1 |
| 6 | Confidentiality | Patients, staff | Breaches of confidentiality as family members in the room during the exercise class | 2 | 2 | 4 | Patients and carer only to be in the room for duration of the class. Carer to stay behind screen where possible. | Y | | 1 | 2 | 2 |
| 7 | Adverse event suffered during exercise | Patients | Acutely unwell due to pre-existing condition or unpredictable acute event | 2 | 6 | 12 | Detailed pre-assessment using guidance from the South West on general principles for remote | Y | | 1 | 3 | 3 |

| | | | | | | | | | |
|--|--|--|---------------------------|--|--|--|--|--|--|
| | | | Distressing for the group | | | <p>pulmonary rehabilitation assessment.</p> <p>Pulse oximeter provided for monitoring.</p> <p>Rockwood score to guide ratio of staff to patients – no more than three patients with score of 5 or above per class if one moderator.</p> <p>Clinician moderating group at all times with phone numbers and addresses available.</p> <p>Patient to be moved into breakout room with moderator whilst action taken.</p> | | | |
|--|--|--|---------------------------|--|--|--|--|--|--|

Consequence X Likelihood = Risk Total (C x L = R)

RED IMMEDIATE ATTENTION REQUIRED Top Priority – must not be allowed to continue

ALL RED risks MUST be reported to Health & Safety Team

ORANGE ATTENTION REQUIRED As soon as possible.

Tel: 08456 598146 (Urgent items/assistance) 07919 401228

YELLOW RISK REDUCTION REQUIRED As soon as reasonably practicable

GREEN NO IMMEDIATE ACTION REQUIRED Risk is tolerable for the time being, needs reviewing regularly, especially after changes.